NASA MARSHALL SPACE FLIGHT CENTER HUNTSVILLE, ALA.

GEMINI PROGRAM SUMMARY

The National Aeronautics and Space Administration announced December 7, 1961, a plan to extend the existing manned spaceflight program by development of a two-man spacecraft. The program was officially designated Gemini on January 3, 1962. It was named after the third constellation of the zodiac, featuring the twin stars Castor and Pollux. The program was operationally completed with the Gemini XII flight.

MUELLER

SCHNEIDER

GILRUTH

MATHEWS

The Gemini program was managed by the Manned Spacecraft Center, Houston, Texas, under direction of the Office of Manned Space Flight, NASA Headquarters, Washington, D.C. Dr. George E. Mueller, Associate Administrator of NASA for Manned Space Flight, served as acting director of the Gemini program. William C. Schneider, Deputy Director of the Office of Manned Space Flight for Mission Operations, served as Mission Director on all Gemini flights beginning with Gemini V.

The Manned Spacecraft Center Gemini effort was headed by Dr. Robert R. Gilruth, director of the Center, and Charles W. Mathews, Gemini Program Manager.

PROGRAM OBJECTIVES

The Gemini Program was conceived after it became evident to NASA officials that an intermediate step was required between Project Mercury and the Apollo Program. The major objectives assigned to Gemini were:

- To subject two men and supporting equipment to long duration flights—a requirement for projected later trips to the moon or deeper space.
- To effect rendezvous and docking with other orbiting vehicles, and to maneuver the docked vehicles in space, using the propulsion system of the target vehicle for such maneuvers.
- To perfect methods of reentry and landing the spacecraft at a pre-selected land-landing point.
- To gain additional information concerning the effects of weightlessness on crew members and to record the physiological reactions of crew members during long duration flights.

A brief summary of each of the Gemini flights follows. A study of the flight results reveals how successful the Gemini Program has been. All of the major objectives have been met as well as many other objectives assigned to each mission, with the exception of land landing which was canceled from the Gemini Program in 1964. However, the precision control necessary to achieve the land landing objective was demonstrated.

GEMINI I

The first Gemini flight, on April 8, 1964, was an unmanned flight with no recovery planned. Primary objectives of that mission were to check the overall dynamic loads on the structural shell spacecraft during the launch phase and to demonstrate the structural compatability of the spacecraft and the Gemini launch vehicle. The spacecraft was not separated from the second stage of the launch vehicle.

The spacecraft was placed in an elliptical orbit with a perigee of 86.6 miles and an apogee of 173 miles. The spacecraft entered the earth's atmosphere during its 64th orbit while over the South Atlantic, and burned up.

In addition to achieving all its major objectives, this flight served to demonstrate the performance of the tracking network, provided training for flight controllers, and demonstrated the operational capabilities of the prelaunch and launch facilities.

GEMINI II

Gemini II, the second and final unmanned flight in the Gemini Program, was a suborbital flight. It was launched from Cape Kennedy January 19, 1965, at 9:04 a.m., EST, and the flight was completed 18 minutes and 16 seconds later.

Gemini II had been scheduled for launch December 9, 1964. On that date the countdown reached zero and the stage one engines were ignited. The launch vehicle's Malfunction Detection System detected technical troubles due to a loss of hydraulic pressure and shut down the engines about one second later.

Primary objectives were to demonstrate the adequacy of the reentry module's heat protection equipment during a maximum reentry heating rate, to demonstrate the structural integrity and capability of the spacecraft from lift-off through recovery, and to demonstrate satisfactory performance of the spacecraft systems. Sequencers simulating crewmen were installed on seat pallets.

During the brief flight, Gemini II attained an altitude of 92.4 miles and traveled 1848 miles down-range. Recovery was effected by the aircraft carrier, USS *Lake Champlain* in the mid-Atlantic one hour and 48 minutes after lift-off. The Gemini II mission served as the final flight qualification of the total Gemini space vehicle prior to manned flights.

GEMINI III

The first manned flight of the Gemini Program was on March 23, 1965. Astronauts Virgil I. Grissom and John W. Young served as command pilot and pilot, respectively. It was a three-orbit mission.

Major objectives of the Gemini III mission were: to demonstrate manned orbital flight in the Gemini spacecraft, to demonstrate and evaluate the capability to maneuver the spacecraft, to demonstrate and evaluate the operation of the worldwide tracking network, to evaluate the performance of spacecraft systems, and to recover the spacecraft and evaluate the recovery system.

GRISSOM YOUNG

Gemini III was launched at 9:24 a.m., EST, on a flight that was to continue four hours, 52 minutes, and 31 seconds. Highlights of the mission were:

- An orbital maneuver over Texas during the first orbit which changed the orbital path of a manned spacecraft for the first time.
- The forward and aft thrusters were fired in series of maneuvers to accomplish minute changes in the orbital path. This occurred over the Indian Ocean during the second orbit.

The maximum apogee during the flight was 121 miles, the lowest perigee, 87.0 miles. The spacecraft landed about 50 miles up-range from the predicted landing point at 2:16:31 p.m., EST. The crew was recovered at 3:28 p.m., and the spacecraft was picked up at 5:03 p.m. The prime recovery ship was the USS *Intrepid.*

GEMINI IV

The Gemini IV mission was a four-day flight during the period June 3-7, 1965. This was the first of three successive long duration missions during the Gemini Program. The flight crew—Astronauts James A. McDivitt and Edward H. White II—was the first American crew to open a spacecraft hatch and have one member participate in extravehicular activity.

The hatch was open for 36 minutes and White was outside the spacecraft for 20 minutes of that time.

MC DIVITT WHITE

Major mission objectives were:

- To demonstrate and evaluate the performance of spacecraft systems for a period of approximately four days in space.
- To evaluate the effects of prolonged exposure to the space environment—a requirement in preparation for missions of longer duration.
- To demonstrate the feasibility of extravehicular activity.
- To execute 11 experiments.

During its flight Gemini VI attained a maximum apogee of 159.9 miles and a low perigee of 86.1 miles. Touchdown, in the western Atlantic, occurred after 97 hours, 56 minutes, and 12 seconds of flight at 12:12:12 p.m., EST, on June 7. The impact point was approximately 50 miles up-range from the prime recovery ship, the USS *Wasp.* The crew recovery was effected at 1:09 p.m., and the spacecraft was recovered at 2:28 p.m.

GEMINI V

During the period August 21-29, 1965, the Gemini V mission was flown. Astronaut L. Gordon Cooper, Jr., was the command pilot, and Astronaut Charles Conrad, Jr., served as pilot for that eight-day flight.

Major objectives of the Gemini V flight were: to demonstrate and evaluate performance of the Gemini spacecraft for a period of eight days; to evaluate the performance of the rendezvous guidance and navigation system, using the radar evaluation pod; and to evaluate the effects of prolonged exposure of the crew to the space environment. In addition, a total of 17 experiments were assigned to the flight. Gemini V also marked the first flight on which fuel cells were used to provide electrical power.

COOPER

CONRAD

Gemini V was launched from Cape Kennedy at 9:00 a.m., EST, August 21. During the early phases, the flight went according to plan but a rapid drop in pressure in the cryogenic storage tanks which supplied the fuel cells required that many of the planned activities be curtailed or abandoned.

Flight Director Christopher C. Kraft, Jr., decided to have Gemini V perform a rendezvous with a "Phantom Agena" target during the third day of the mission. Cooper and Conrad were instructed to perform four maneuvers during a period of two revolutions. These maneuvers were accomplished and ground tracking indicated that the simulated rendezvous maneuver would have placed the spacecraft within three-tenths of a mile of the target.

During the flight, Gemini V attained a maximum apogee of 188.9 miles and a low perigee of 87.4 miles. Following retrofire the Gemini V spacecraft touched down in the western Atlantic approximately 90 miles short of the predicted impact point. The touchdown time was 7:55:14 a.m., EST, August 29, following a flight which had lasted 190 hours, 55 minutes and 14 seconds. The crew was recovered at 9:26 a.m., and the spacecraft was picked up by the prime recovery ship, the USS *Lake Champlain,* at 11:50 a.m.

GEMINI VI

Gemini VI was scheduled for launch by NASA October 25, 1965. On that date the Gemini Agena Target Vehicle and the target launch vehicle lifted off from the launch pad at 10:00:04 a.m., EST.

At that time the Gemini VI spacecraft was being readied for launch and the flight crew, Astronauts Walter M. Schirra, Jr., and Thomas P. Stafford, were inside the spacecraft and participating in the countdown.

Six minutes and 16 seconds after lift-off a propulsion failure and subsequent breakup of the target vehicle occurred. The flight of Gemini VI was postponed and later re-scheduled to fly during the time Gemini VII was in space.

GEMINI VI-A

On December 15, 1965, Gemini VI-A was launched from Cape Kennedy at 8:37:26 a.m., EST. Command pilot Schirra and Pilot Stafford had as their primary objective a rendezvous with the Gemini VII spacecraft during the fourth revolution of their flight.

Other objectives were to conduct station keeping exercises with Gemini VII, to evaluate the reentry guidance capability of the spacecraft and to conduct a limited number of experiments.

Three days earlier, Schirra and Stafford had been ready and waiting in their spacecraft. The countdown had proceeded uninterrupted toward the scheduled ignition and the subsequent liftoff at 9:54:06 a.m. Ignition occurred on time but the engines were automatically shut down 1.2 seconds later. Schirra and Stafford correctly assessed the situation and determined it was safe to remain in the spacecraft. It was later determined that a small electric plug in the tail of the launch vehicle had dropped out prematurely, and that a plastic dust cover had obstructed the oxidizer inlet line of a gas generator. Either of these would have prevented liftoff.

SCHIRRA

STAFFORD

Schirra completed a number of maneuvers which resulted in Gemini VI-A rendezvousing with Gemini VII and performing station keeping exercises five hours and 56 minutes after lift-off. During the station keeping period which lasted five hours, 18 minutes, and 29 seconds the two spacecraft were maneuvered so that less than a foot separated them. The highest apogee reached was 168.1 miles, lowest perigee, 86.9 miles.

Gemini VI-A touched down in the western Atlantic 25 hours, 51 minutes, and 24 seconds after its launch. The impact point was within seven miles of the planned landing point. Schirra and Stafford elected to remain with the spacecraft until it was picked up by the USS *Wasp,* the prime recovery ship. The pick-up time was at 11:32 a.m., EST.

GEMINI VII

Astronauts Frank Borman and James A. Lovell, Jr., were command pilot and pilot, respectively of Gemini VII, longest manned space flight in history through the close of the Gemini Program.

Gemini VII, a 14-day mission, was primarily designed to conduct long duration flight and to evaluate the effects on the crew. In addition, they provided a target for Gemini VI-A, conducted station keeping with the spacecraft, conducted 20 experiments, conducted the mission in lightweight pressure suits, and evaluated the spacecraft reentry guidance capability.

BORMAN

LOVELL

Gemini VII was launched from Cape Kennedy at 2:30:03 p.m., EST, December 4, 1965, and touched down in the western Atlantic recovery zone, just 6.4 miles from the planned landing point at 9:05:34 a.m., EST, on December 18, after a flight which had lasted 330 hours, 35 minutes, and one second. The USS *Wasp* recovered the second crew of Gemini astronauts within a three-day period. Borman and Lovell went aboard the *Wasp* in a helicopter at 9:37 a.m., and their spacecraft was taken aboard at 10:08 a.m.

During the flight, Gemini VII attained a maximum apogee of 177.1 miles and a low perigee of 87.2 miles.

Lovell removed his pressure suit on the second day and from that time until the end of the flight either one or both of the crewmen were out of their suits most of the time. The total elapsed time of the flight was about twice that anticipated necessary for a lunar landing mission.

GEMINI VIII

Gemini VIII was launched from Cape Kennedy March 16, 1966. Neil A. Armstrong was command pilot and David R. Scott, pilot, of the flight which established several records prior to its early termination.

The Gemini VIII Agena target vehicle was launched from the Cape at 10:00:03 a.m., EST. This launch was followed by that of Gemini VIII at 11:41:02 a.m., as scheduled.

ARMSTRONG

SCOTT

Six hours after lift-off the rendezvous of a spacecraft and an unmanned target vehicle had been effected for the first time. This was followed shortly by the first docking of two vehicles in space. The elapsed flight time of this historic event was six hours, 33 minutes, and 22 seconds after the Gemini VIII lift-off.

Approximately 27 minutes after docking, the spacecraft-target vehicle combination encountered greater than expected yaw and roll rates. They attempted to bring the vehicles under control by giving various commands to the Agena. When it became evident this action would not be effective, Armstrong and Scott suspected some part of the spacecraft control system might be involved.

The rates increased to a point where the crew felt the structural integrity of the combination might be in jeopardy, and they then succeeded in reducing the rates to a point where they could safely undock from the target and back away as quickly as possible.

After completing this maneuver it was evident that the spacecraft's attitude control system had caused the problem. Roll and yaw rates of the spacecraft rapidly increased to such an extent that it was making almost one full revolution per second. The roll was brought under control by deactivating the orbital attitude maneuver system and by activating the reentry control system.

Flight Director John D. Hodge assessed the situation, and ordered the mission terminated during the seventh revolution. This required a landing in a secondary recovery area in the Pacific. Gemini VIII touched down in the western Pacific, east of Okinawa, after an elapsed flight time of 10 hours, 41 minutes, and 26 seconds. Touchdown was about 1.1 miles south of the planned landing area at 10:22:28 p.m., EST. The crew was picked up by the USS *Mason,* a destroyer, at 1:28 a.m., EST, March 17, and the spacecraft was picked up an hour and nine minutes later.

GEMINI IX

Gemini IX was scheduled to be another rendezvous mission. The Agena target was launched from Cape Kennedy May 17, 1966, at 10:15:03 a.m., EST. The target launch vehicle booster engine number two pitch control was lost two minutes and one second after lift-off and the Gemini IX mission was terminated.

The assigned crew—Astronaut Thomas P. Stafford, command pilot, and Astronaut Eugene A. Cernan, pilot—left their spacecraft and returned to a training schedule for the flight which was scheduled for June 1, using an Augmented Target Docking Adapter as the target vehicle.

GEMINI IX-A

On June 1, the target vehicle for Gemini IX-A was launched from Cape Kennedy at 10:00:02 a.m., EST, and was successfully placed into an orbit with an apogee of 161 miles and a perigee of 159 miles.

The flight crew was in the spacecraft and participated in the countdown. Stafford and Cernan were ready to go and then, there was a hold initiated at T minus one minute and 40 seconds. The count was recycled to T minus three minutes. Launch Control announced that the guidance system update of the spacecraft computer could not be transferred from the ground equipment to the spacecraft. After two additional holds for the same cause, Mission Director William Schneider postponed the launch attempt and rescheduled it for June 3.

STAFFORD

CERNAN

That day, the countdown went smoothly and Gemini IX-A was launched at 8:39:33 a.m., EST. Major objectives of the mission were to rendezvous with the target during the third revolution, to re-rendezvous during the fourth revolution, to rendezvous from above during the 12th revolution, to conduct extravehicular activities, to demonstrate a controlled reentry, and to conduct docking practice. All of these objectives except the last were achieved.

Gemini IX-A rendezvoused with the ATDA four hours and 15 minutes after lift-off and performed station keeping activities 46 minutes. Stafford and Cernan re-rendezvoused with the target after six hours and 36 minutes of the mission had elapsed. This time the period of station keeping lasted 39 minutes.

The third rendezvous (from above) was the most difficult to achieve because of the terrain in the background. This rendezvous was accomplished after 21 hours and 42 minutes of flight and the station keeping period lasted one hour and 17 minutes.

The hatch was open for extravehicular activity 49 hours and 23 minutes after lift-off and the hatch was closed again after 51 hours and 30 minutes—a total extravehicular time of two hours and seven minutes.

The Gemini IX-A spacecraft touched down in the western Atlantic 72 hours, 20 minutes, and 50 seconds after lift-off at 9:00:33 a.m., EST, June 6. It landed an estimated .38 miles west of the planned landing point. During the flight Gemini IX-A reached a high apogee of 168.2 miles, a low perigee of 85.7 miles. The crew and spacecraft were recovered by the USS *Wasp* at 9:53 a.m.

GEMINI X

Astronauts John W. Young and Michael Collins were command pilot and pilot, respectively, for the Gemini X mission. The flight was conducted July 18-21, 1966. The major objectives of the flight were: to rendezvous and dock with an Agena target vehicle, to use large propulsion systems in space, to conduct extravehicular activities, and to conduct docking practice. These objectives, with the exception of the last, were achieved.

On July 18, the Agena target was launched at 3:39:46 p.m., EST.

This was followed by the Gemini launch at 5:20:27 p.m. This followed the flight plan exactly and allowed the Gemini X spacecraft to rendezvous with its target five hours and 21 minutes later. The docking of the two craft was accomplished 31 minutes later and the two vehicles operated in the docked configuration for 38 hours and 47 minutes. During this period of time they performed six major maneuvers, three of which used the Agena's primary propulsion system and three which used the Agena's secondary propulsion system. The first of the major maneuvers placed the Gemini X-Agena X in an elliptical orbit with an apogee of 412.2 miles and a perigee of 158.5 miles. During the docked period, the Gemini X crew participated in the first of two major extravehicular activities. This occurred after 23 hours and 24 minutes

YOUNG

COLLINS

of the flight had elapsed. The hatch was open 49 minutes during which time Collins performed tasks assigned to that phase of the mission. The standing EVA was terminated when both crew members experienced eye irritation.

The second EVA period started 48 hours and 41 minutes after lift-off. This was an umbilical EVA activity with Collins emerging from the spacecraft and lasted 39 minutes. During this time Collins retrieved an experiment package which had been attached to the Agena VIII since March.

The crew un-docked from the Agena X target after 44 hours and 40 minutes of flight and prepared to rendezvous with the Agena VIII target vehicle which had been in a parking orbit since March 16.

The highest apogee reached during the flight was 412.2 miles and the lowest perigee, 86.3 miles. The Gemini X spacecraft touched down in the Atlantic at 4:07:06 p.m., EST, July 21, at an estimated 3.4 miles from the planned impact point. The crew chose to be recovered by helicopter and they were landed aboard the USS *Guadalcanal* 27 minutes after landing. Another 27 minutes passed before the *Guadalcanal* picked up the Gemini X spacecraft.

GEMINI XI

Astronauts Charles Conrad, Jr., and Richard F. Gordon, Jr., served as command pilot and pilot, respectively, of the Gemini XI mission which was conducted September 12-15, 1966. The Atlas-Agena was launched at 8:05:02 a.m., and at 9:42:26.5 a.m. the Gemini liftoff occurred.

Gemini XI had an ambitious flight plan and most of the mission objectives were achieved. One of the most important accomplishments of the flight was the successful rendezvous and docking with the Agena target vehicle during the spacecraft's first revolution.

Another important achievement of the Gemini XI mission was that of attaining the highest altitude ever reached in a manned flight. During the second day of the mission, and while docked with the Agena, the Agena's primary propulsion system was fired up and boosted the combined vehicles into an elliptical orbit with an apogee of 739.2 miles and a perigee of 156.3 miles.

CONRAD

GORDON

Gordon completed fastening the tether to the spacecraft's docking bar during his umbilical EVA at the expense of a great amount of energy and the crew decided to terminate that activity because of pilot fatigue. The hatch was open 33 minutes.

Shortly after the third day of the flight was started, the Gemini XI crew racked up another first. They undocked from the Agena and started a successful tethered operation. The two spacecraft made about two revolutions around the earth while fastened together.

There were other notable achievements of the Gemini XI flight. For the first time in manned space flight history the rendezvous was accomplished by using onboard computations. Docking practice was carried out for the first time in space as both the command pilot and the pilot performed the docking maneuvers twice.

Another important first—the automatic reentry—was attempted for the first time in the Gemini program. Retrofire occurred over the Canton Island tracking station at an elapsed time of 70 hours, 41 minutes, and 36 seconds. The impact was achieved about 35 minutes later, approximately one-and-a-half miles from the prime recovery ship, the USS *Guam*. Conrad and Gordon were taken to the *Guam* by helicopter 24 minutes after they landed, and the spacecraft was retrieved 59 minutes after landing.

GEMINI XII

The final flight of the Gemini Program began November 11, 1966, and ended four days later. On launch day the Atlas-Agena liftoff occurred at 2:07:59 p.m., one second earlier than planned. This launch was followed by the Gemini liftoff at 3:46:33 p.m., within a half-second of the planned time.

Gemini XII was designed to gain additional information about the extravehicular activity requirements, to rendezvous and dock with a target, and to perform a number of experiments. The final Gemini flight was an unqualified success.

LOVELL

ALDRIN

In addition to achieving these and other objectives command pilot James A. Lovell, Jr., and pilot Edwin E. Aldrin, Jr., set several individual space records. Lovell has logged more hours in space flight than any other man—425 hours, nine minutes, and 31 seconds. Aldrin logged more extravehicular time than any man—a two hour, 29-minute standup EVA; a two hour and six-minute umbilical EVA; and another 55-minute standup EVA for a total of five hours and 32 minutes.

A total of 14 experiments were performed. These activities were spread over the four-day flight period.

Use of handrails, foot restraints, and waist tethers during the umbilical EVA period proved to be most effective and Aldrin completed all 19 assigned tasks.

Retrofire was initiated over Canton Island at 93 hours, 59 minutes, and 58 seconds elapsed time. The landing occurred 34 minutes and 32 seconds later at 2:21:04 p.m. within 2.6 miles of the planned landing point. The flotation collar was attached eight minutes after impact and Lovell and Aldrin were picked up by helicopter and taken to the deck of the USS *Wasp* at 2:49 p.m. The last Gemini spacecraft to fly in the program was brought aboard the *Wasp* at 3:28 p.m., November 15, 1966.

EXPERIMENTS

There were a total 51 experiments scheduled for investigation during the Gemini Program. Many of these experiments were carried on more than one flight and 40 of them were completed. Results of the experiments will be published in later documents.

Following are a list of the experiments, the basic objectives of each, and missions carrying them:

- Cardiovascular Conditioning — to determine the effectiveness of pneumatic cuffs as a preventative measure for the heart and blood distribution system deterioration induced by prolonged weightlessness, and to establish the occurrence and degree of heart and blood distribution system deterioration induced by prolonged weightlessness, (V, VII).
- In-Flight Exerciser — to assess the capacity of an astronaut to perform a measured amount of work in the space environment, (IV, V, VII).
- In-Flight Phonocardiogram — to serve as an indicator of heart muscle deterioration when compared with a simultaneous electrocardiogram, (IV, V, VII).
- Bioassays of Body Fluids — to determine astronauts' reactions to stress requirements of space flight by analysis of hormones, (VII, VIII, IX-A).
- Bone Demineralization — to establish the occurrence and degree of bone demineralization as a result of prolonged weightlessness by a direct X-rays technique, (IV, V, VII).
- Calcium Balance Study — to establish the rate and amount of calcium lost to the body under conditions of orbital flight, (VII).
- In-Flight Sleep Analysis — to assess the state of alertness, level of consciousness, and depth of sleep of astronauts in-flight, (VII).
- Human Otolith Function — to measure changes in the otolith (gravity sensors in inner ear) function and to determine astronauts' orientation capability under dark conditions during prolonged weightlessness, (V, VII).
- Electrostatic Charge — to detect and measure any accumulated electrostatic charge that may be created on the spacecraft surface by ionization from engine exhausts, (IV, V).
- Proton Electron Spectrometer — to measure the radiation immediately outside the spacecraft while in orbit, (IV, VII).
- Tri-Axis Magnetometer — to monitor the direction and amplitude of the earth's magnetic field with respect to the spacecraft, (IV, VII, X, XII).
- Basic Object Photography — to investigate techncial problem areas associated with man's ability to observe, evaluate, and photograph objects in space, (V).
- Nearby Object Photography — to demonstrate human proficiency and spacecraft functional compatability in space while maneuvering, station keeping and observing in a manual control mode, (V).
- Mass Determination — to investigate the feasibility of a direct contact method of determining the mass of an orbiting vehicle, (XI).
- Celectial Radiometry — to provide information on the spectral analysis of regions of interest, supplied by the star fields, the principal planets, the earth and the moon, (V, VII).
- Surface Photography — to investigate problems associated with man's ability to acquire, track, and photograph terrestrial objects, (V).
- Space Object Radiometry — to measure the radiometric intensity of space objects such as the Agena target vehicle, (V, VII).
- Radiation in Spacecraft — to make accurate measurements of absorbed dose rate and total dose inside the spacecraft, to evaluate dosimeters of radiation in space, and to study the distribution of dose levels inside the astronaut and inside the spacecraft, (IV, VI-A).
- Simple Navigation — to develop and test sighting procedures for development of an on-board, manual navigation system, and to obtain information on the accuracies of horizon determination, use of a green line as horizon, and astronaut experience in sighting, (IV, VII).
- Astronaut Visibility — to measure the ability of astronauts to identify ground objects under controlled conditions, (V, VII).
- Zodiacal Light Photography — to obtain color photographs of the zodiacal light (a cloudy, hazy, misty light seen in the west after twilight and in the east before dawn) and the airglow (a faint background illumination of the night sky), (V, IX-A, X).
- Sea Urchin Egg Growth — to evaluate the effects of zero-G orbital environment on the growth of simple cells, (III).
- Radiation and Zero-G Effects on Blood — to determine whether or not a combined action relationship exists between the effects of weightlessness and radiation on human white blood cells, (III, XI).
- Synoptic (Wide Angle) Terrain Photography — to obtain high-quality, small scale photographs of selected parts of the earth's surface for use in re-

search in geology, geophysics, geography, oceanography, and other fields, and for use in planning photography for future space programs, (IV, V, VI-A, X, XI, XII).

- Synoptic (Wide Angle) Weather Photography — to learn about the earth's weather systems as revealed by the detail possible from high-quality cloud photographs made selectively, (IV, V, VI-A, X, XI, XII).

- Cloud Top Spectrometer — to obtain quantitative information on atmospheric oxygen absorption in support of a method under development for determining cloud top altitudes from meterological satellites, (V).

- Visual Acuity — to investigate the limiting visual performance of the astronauts in the detection and recognition of objects on the earth's surface with and without the assistance of a magnifying device, (V, VII).

- Nuclear Emulsion — to perform a qualitative study of the heavy particles in the galactic cosmic radiation, and to study the trapped proton flux of the Van Allen belts in the vicinity of South America, (XI).

- Airglow Horizon Photography — to study the spectra of the airglow on a global scale, (IX-A, XI, XII).

- Micrometeorite Collection — to collect micrometeorites to study the physical and chemical nature of interplanetary dust in its primary form, (IX-A, X, XII).

- Night Image Intensification — to test the usefulness and performance of a low-light-level television system as a supplement to unaided vision in observing surface features primarily when such features are in darkness and spacecraft pilots are not dark-adapted, (XI).

- Ultraviolet Astronomical Camera — to test the techniques of ultraviolet photography under vacuum conditions and to obtain ultraviolet radiation observations of stars in the wave length region of 2000 to 4000 Angstroms by spectral means, (X, XI, XII).

- Ion Wake Measurement — to determine and measure the ion and electron wake structure and perturbation of the ambient medium produced by an orbiting vehicle, (X, XI).

- Dim Light Photography/Orthicon — to obtain photographs of various faint and diffuse astronomical phenomena such as airglow layer in profile, brightest Milky Way, zodiacal light at 60-degree elongation, counterglow, and the LaGrangian libration points of the earth-moon system, (XI).

- Reentry Communications — to determine whether injection of water into the plasma sheath during the reentry blackout would permit communications to be continued during that period, (III).

- Two-Color Earth's Limb Photography — to photograph the earth's limb on black and white film with a hand-held camera using red and blue filters in order to determine whether the high altitude blue limb is a reliable sighting feature for use in spaceflight guidance and navigation, (IV).

- Frog Egg Growth — to determine the effect of weightlessness on the ability of the fertilized frog egg to divide normally and to differentiate and form a normal embryo, (VIII, XII).

- Astronaut Maneuvering Unit — one approach to determine the basic hardware and operational criteria required to integrate into manned space flight such activities as maintenance, repair, resupply, crew transfer, rescue, satellite inspection, and assembly in space, (IX-A).

- UHF/VHF Polarization Measurements — to measure the electron content of the ionosphere below the spacecraft and in particular the electron content in homogeneities which exist along the orbital path of the spacecraft, (IX-A).

- Agena Micrometeorite Collection — to study the micrometeorite content of the upper atmosphere and near-earth space environment, (IX-A, X).

- Ion-Sensing Attitude Control — to investigate the feasibility of an attitude control system using environmental positive ions and an electrostatic detection system to measure pitch and yaw, (X-XII).

- Beta Spectrometer — to determine the radiation environment external to the spacecraft, X, XII).

- Bremsstrahlung Spectrometer — to determine the Bremsstrahlung flex-energy spectra inside the Gemini spacecraft while passing through the South Atlantic Magnetic Anamoly regions, (X, XII).

- Color Patch Photography — to determine if existing photographic materials can accurately reproduce the color of objects photographed in space, (XI).

- Landmark Contrast Measurements — to measure the visual contrast of landmarks against their surroundings in order to determine the relative visibility of terrestrial landmarks from outside the atmosphere, (VII- IX-A).

- Star Occultation Navigation — to determine the usefulness of star occultation measurements for space navigation and to establish a density profile for updating atmospheric models for horizon-based measurement systems, (VII, X).

- Optical Communications — to evaluate an optical communications system, to evaluate the crew as a pointing element, and to probe the atmosphere using an optical coherent radiator outside the atmosphere, (VII).

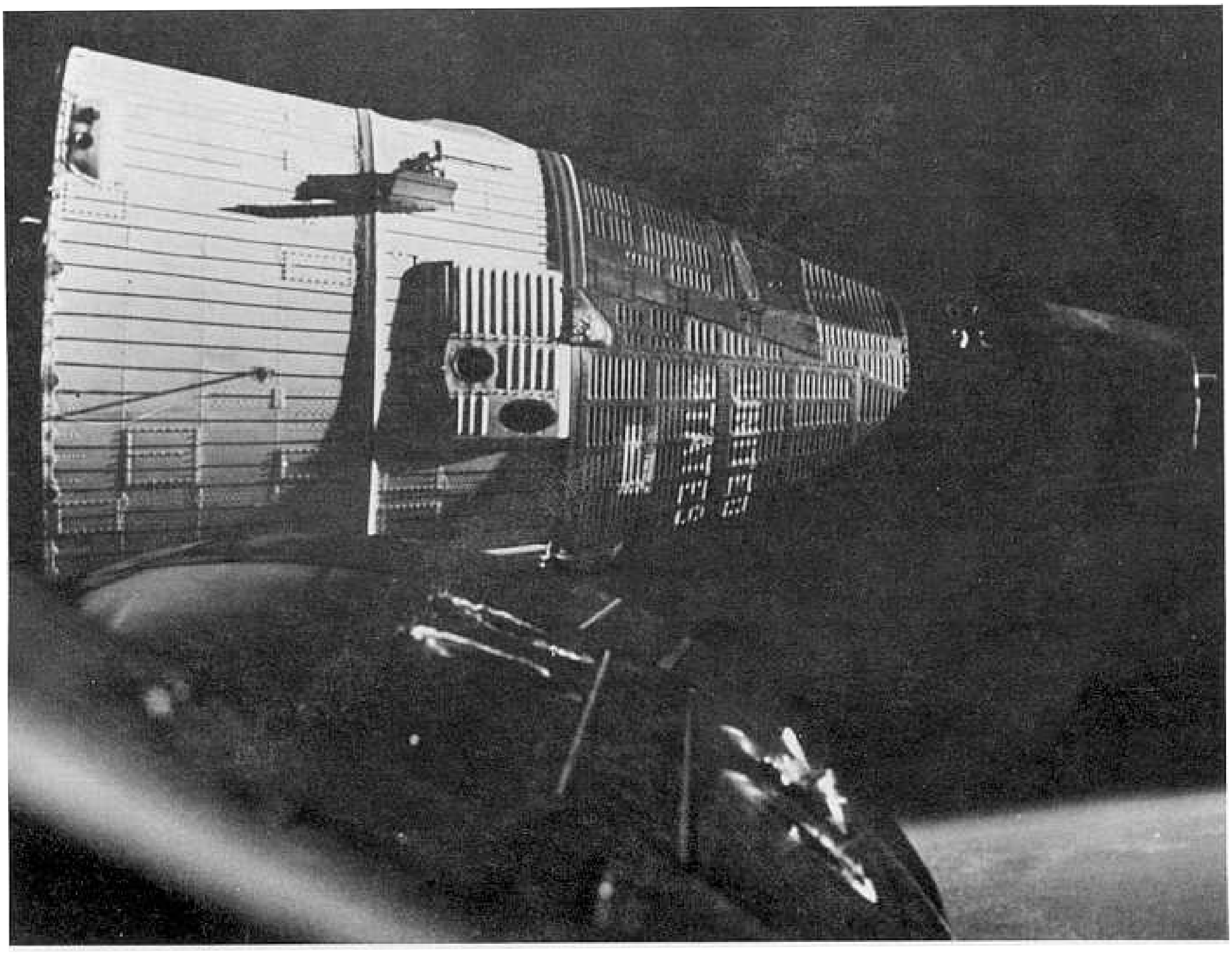
- Libration Regions Photographs — to obtain photographs of libration points on the moon to investigate the possible existence of clouds of particles orbiting the earth in these regions, (XII).

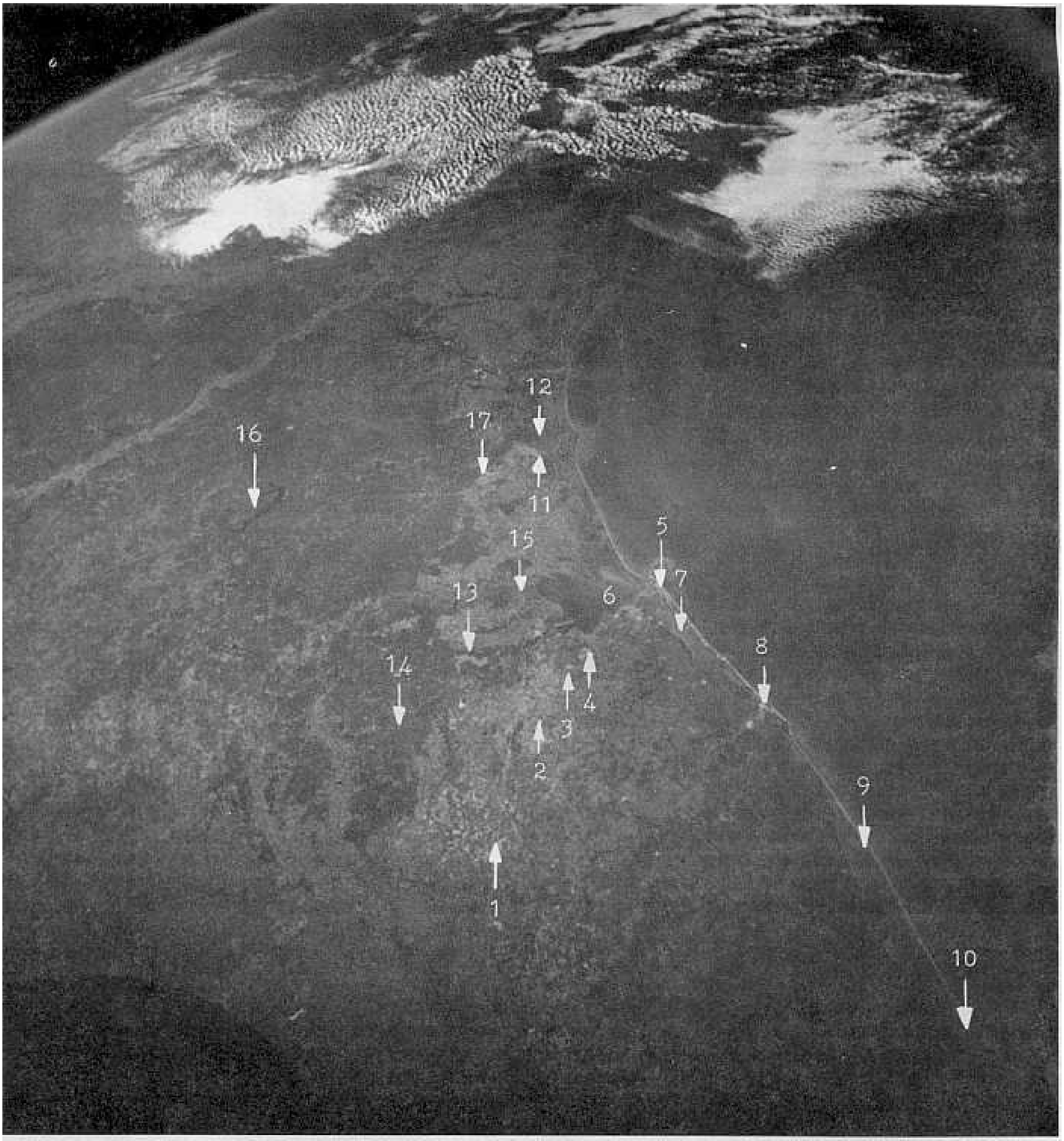
- Sodium Vapor Cloud — to study the feasibility of orbital photography of a sodium vapor cloud, (XII).

- Manual Navigation Sightings — to determine the feasibility of using an onboard sextant for accurate spacecraft navigation, (XII).

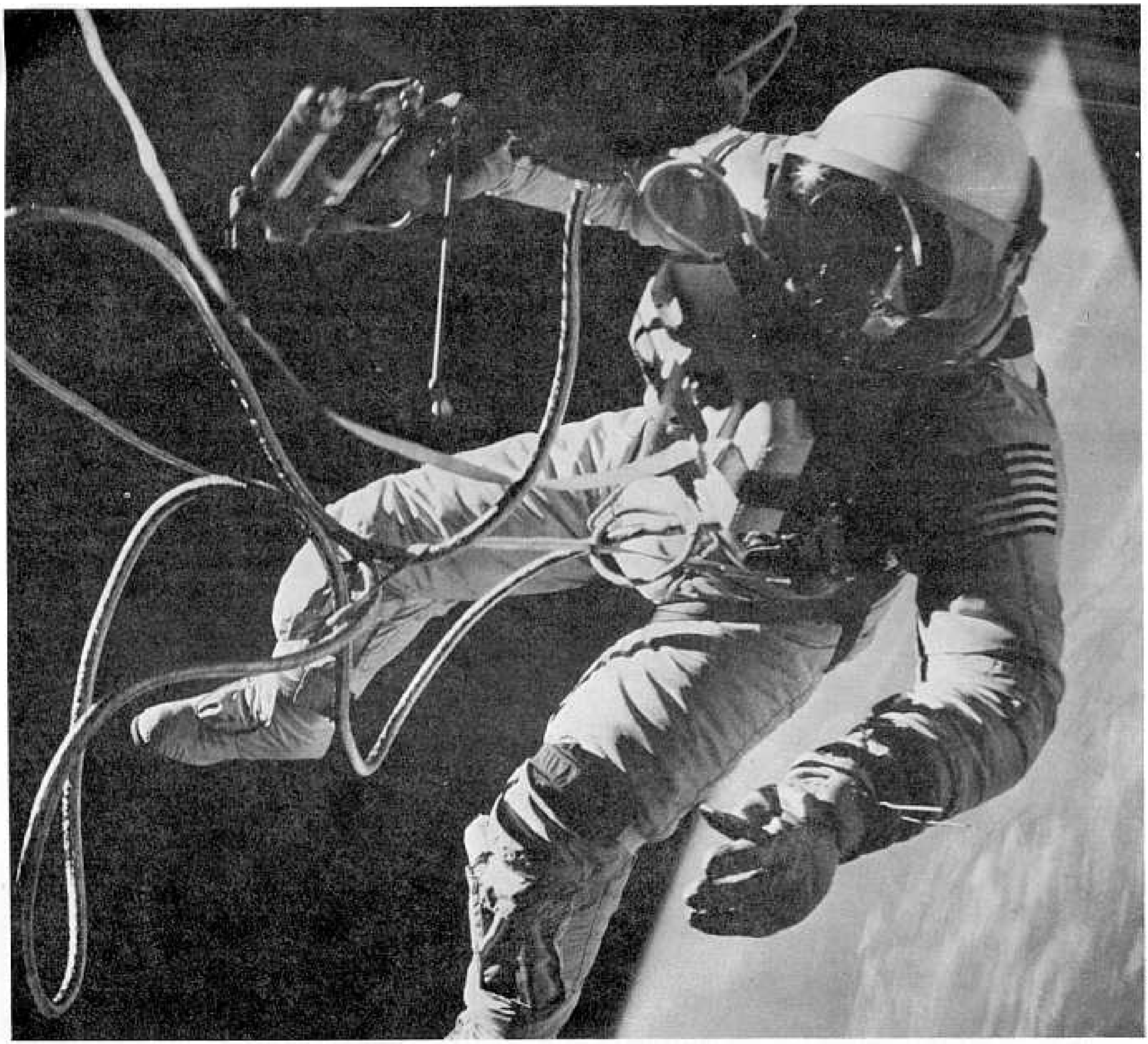
- Lunar UV Spectral Reflectance — to determine the ultraviolet spectral reflectance of the lunar surface in wave lengths from 2000 to 3200 Angstroms, (XII).

ONE OF THE MAJOR ACCOMPLISHMENTS OF THE Gemini Program was rendezvous. The photo above shows the enthusiasm generated in Mission Control Center at Houston following the first successful rendezvous in history — that of Gemini VI-A and Gemini VII. Small American flags were "raised" above all the Control Center consoles to mark the historic achievement.





IT SEEMS APROPOS THAT excellent photography of the Houston area should have been obtained on the final Gemini flight since mission control of all flights was exercised from that location starting with Gemini IV. Points of interest in the photo above are: (1) Interstate Highway 10, (2) the Astrodome, (3) Gulf Freeway, (4) Manned Spacecraft Center, (5) Galveston, (6) Galveston Bay, (7) West Bay, (8) Freeport, (9) Matagorda Bay, (10) West Matagorda Bay, (11) Port Arthur, (12) Sabine Lake, (13) Lake Houston, (14) Interstate Highway 45, (15) Interstate Highway 10, (16) Sam Rayburn Reservoir, and (17) Beaumont.



LOG OF GEMINI SPACE FLIGHTS

MISSION	PILOTS	DATE(S)	ELAPSED TIME	TOTAL U.S. MANNED HOURS IN SPACE
Gemini-Titan III	Grissom-Young	Mar. 23, '65	04:52:31	63:00:29
Gemini-Titan IV	McDivitt-White	June 3-7, '65	97:56:12	258:52:53
Gemini-Titan V	Cooper-Conrad	Aug. 21-29, '65	190:55:14	640:43:21
Gemini-Titan VII	Borman-Lovell	Dec. 4-18, '65	330:35:01	1301:53:23
Gemini-Titan VI-A	Schirra-Stafford	Dec. 15-16, '65	25:51:24	1353:36:11
Gemini-Titan VIII	Armstrong-Scott	Mar. 16, '66	10:41:26	1374:59:03
Gemini-Titan IX-A	Stafford-Cernan	June 3-6, '66	72:20:50	1519:40:43
Gemini-Titan X	Young-Collins	July 18-21, '66	70:46:39	1661:14:01
Gemini-Titan XI	Conrad-Gordon	Sep. 12-15, '66	71:17:08	1803:48:17
Gemini-Titan XII	Lovell-Aldrin	Nov. 11-15, '66	94:34:31	1992:57:19

GEMINI

GEMINI III
MARCH 23, 1965
Gus Grissom
VIRGIL I. GRISSOM
John Young
JOHN W. YOUNG

GEMINI IV
JUNE 3, 1965
James A. McDivitt
JAMES A. McDIVITT
Edward H. White II
EDWARD H. WHITE, II

GEMINI V
AUGUST 21, 1965
Gordon Cooper
L. GORDON COOPER
Charles Conrad
CHARLES CONRAD

GEMINI VI-A
DECEMBER 15, 1965
Wally Schirra
WALTER M. SCHIRRA
Thomas P. Stafford
THOMAS P. STAFFORD

GEMINI VII
DECEMBER 4, 1965
Frank Borman
FRANK BORMAN
Jim Lovell
JAMES A. LOVELL

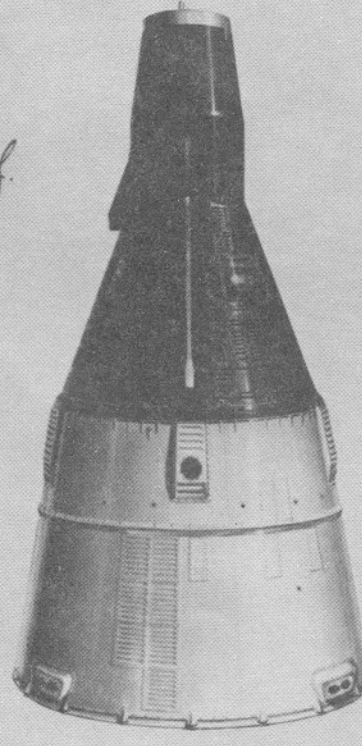
GEMINI VIII
MARCH 16, 1966
NEIL A. ARMSTRONG
Dave Scott
DAVID R. SCOTT

GEMINI IX-A
JUNE 3, 1966
Thomas P. Stafford
THOMAS P. STAFFORD
Gene Cernan
EUGENE A. CERNAN

GEMINI X
JULY 18, 1966
John Young
JOHN W. YOUNG
Michael Collins
MICHAEL COLLINS

GEMINI XI
SEPTEMBER 12, 1966
Charles Conrad
CHARLES CONRAD
R. F. Gordon
RICHARD F. GORDON

GEMINI XII
NOVEMBER 11, 1966
Jim Lovell
JAMES A. LOVELL
Edwin E. Aldrin Jr.
EDWIN E. ALDRIN


GEMINI SPACECRAFT